Requested Patent: GB2196211A

Title: COMMUNICATIONS SYSTEM FOR A MOBILE VIDEO CAMERA ;

Abstracted Patent: GB2196211 ;

Publication Date: 1988-04-20 ;

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Applicant(s): BRITISH BROADCASTING CORP ;

Application Number: GB19870021157 19870909 ;

Priority Number(s): GB19860021997 19860912 ;

IPC Classification: H04B7/06 ;

Equivalents: ;

ABSTRACT:

A mobile television camera is fitted with an array 12 of antennae 1 to 6 to transmit a video signal to a fixed receiver. In each field blanking interval of the video signal, a known f.m, test signal 24 is transmitted from each antenna in turn. At the receiver the signal from each antenna is detected 52, the signal strength is measured, and the degree of multipath distortion measured 54 by determining the a.m. ripple by on the envelope of the f.m. signal (see Fig. 4). The antenna giving the best signal in terms of both signal strength and degree of multipath distortion is determined. A control signal is then transmitted 56 back to the mobile camera over a separate v.h.f. radio link 30 to select the antenna giving the best signal to transmit the next video field.

(12) UK Patent Application (19) GB (11) 2 196 211 (13) A

(43) Application published 20 Apr 1988

(21) Application No 8721157

(22) Date of filing 9 Sep 1987

(30) Priority data
(31) 8621997 (32) 12 Sep 1986 (33) GB

(51) INT CL⁴
H04B 7/06

(52) Domestic classification (Edition J):
H4L 27H7B DDS
U1S 2204 2222 H4L

(56) Documents cited
EP A2 0158327

(58) Field of search
H4L
Selected US specifications from IPC sub-class H04B

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(54) Communications system for a mobile video camera

(57) A mobile television camera is fitted with an array 12 of antennae 1 to 6 to transmit a video signal to a fixed receiver. In each field blanking interval of the video signal, a known f.m. test signal 24 is transmitted from each antenna in turn. At the receiver the signal from each antenna is detected 52, the signal strength is measured, and the degree of multipath distortion measured 54 by determining the a.m. ripple by on the envelope of the f.m. signal (see Fig. 4). The antenna giving the best signal in terms of both signal strength and degree of multipath distortion is determined. A control signal is then transmitted 56 back to the mobile camera over a separate v.h.f. radio link 30 to select the antenna giving the best signal to transmit the next video field.

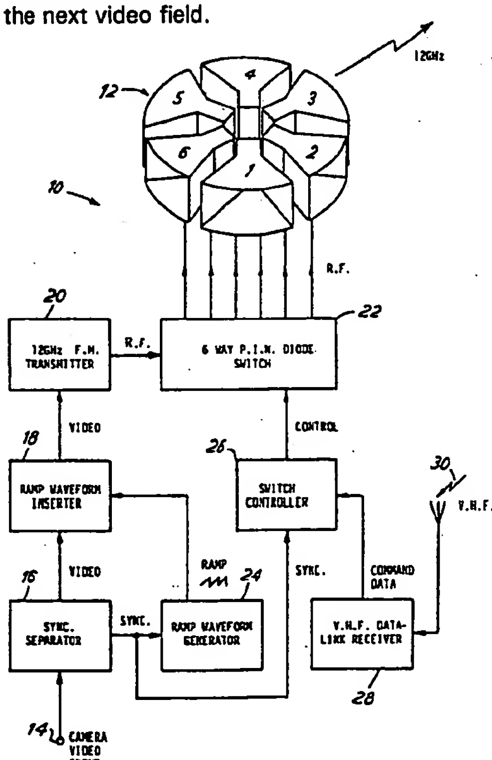

FIG.1

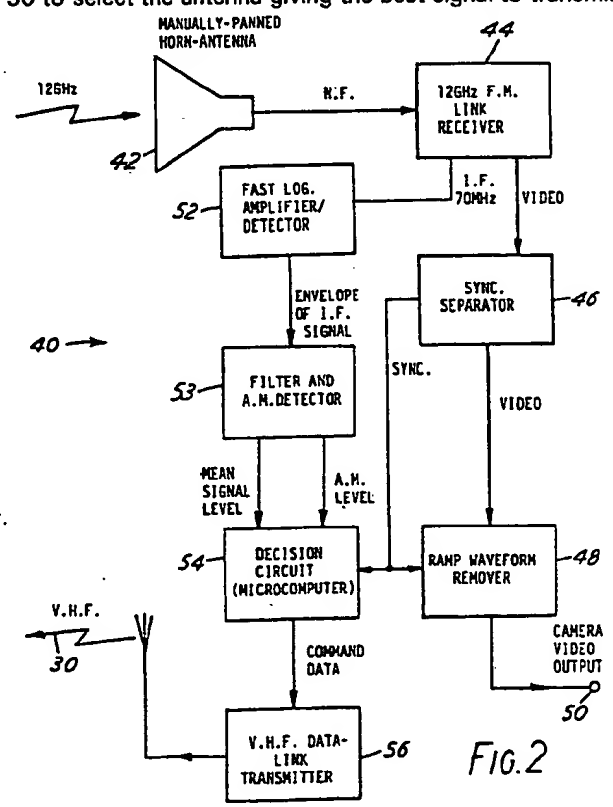

FIG.2

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1/3

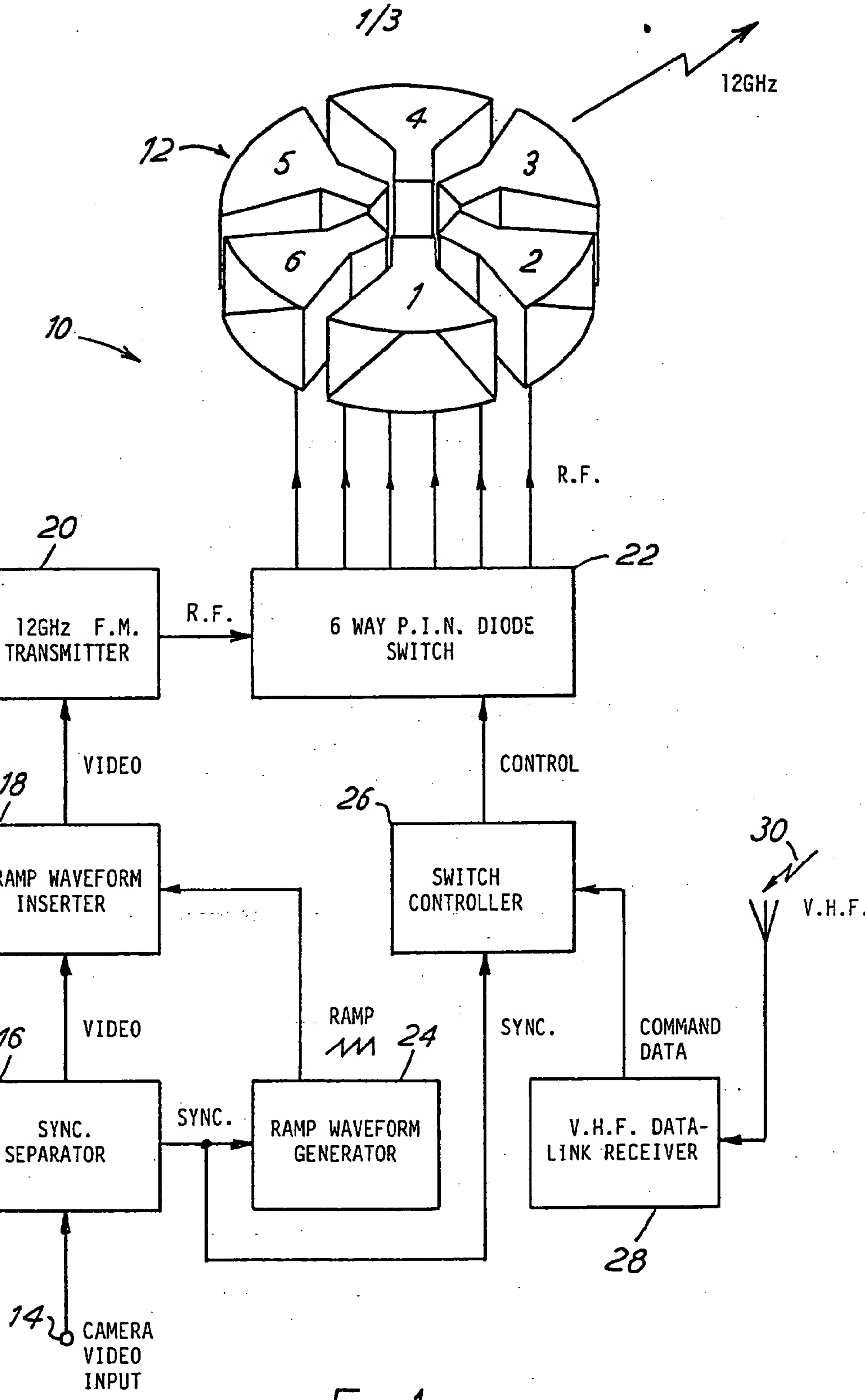

FIG. 1

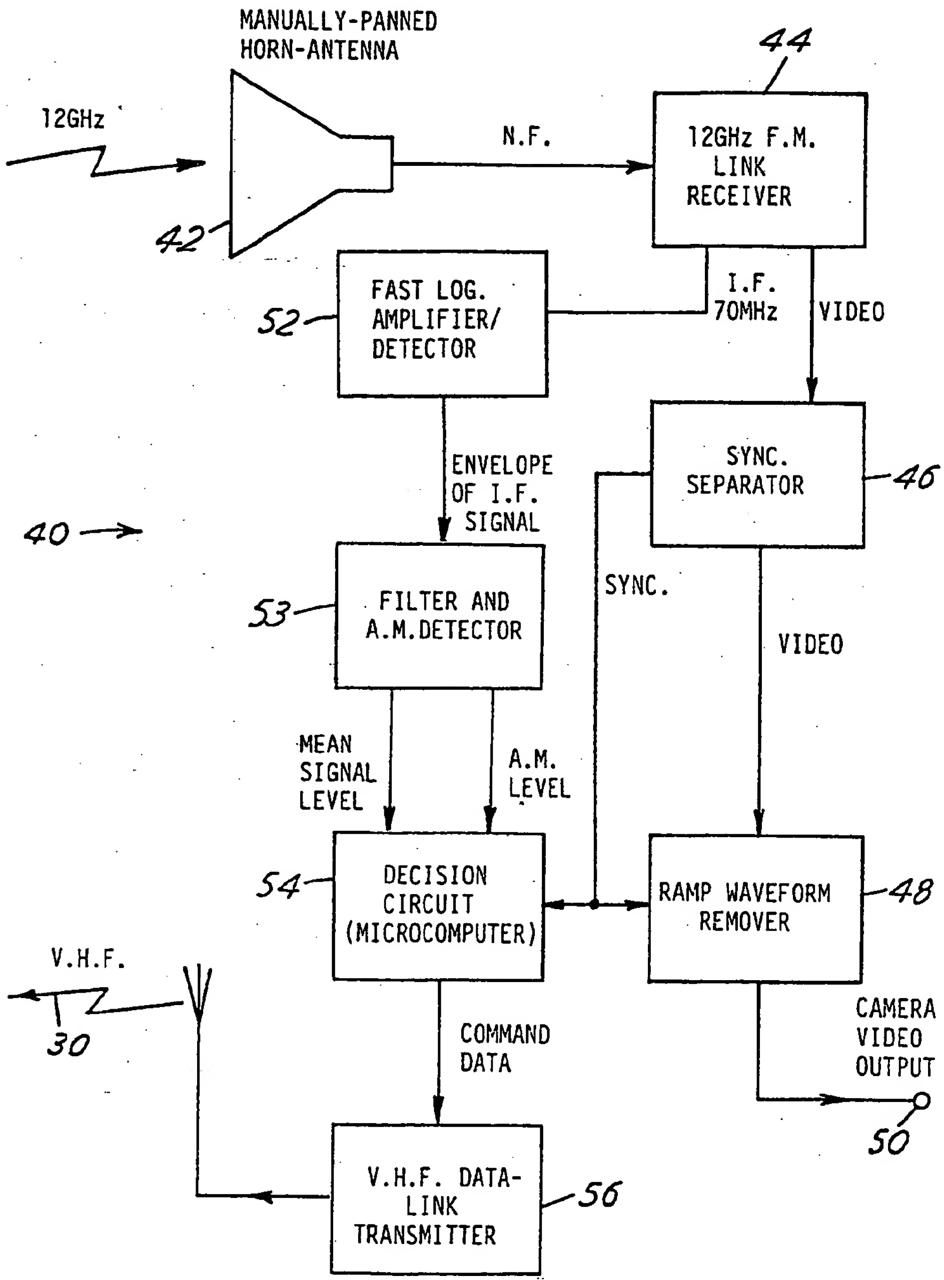
MANUALLY-PANNED HORN-ANTENNA
12GHz
N.F.
44
12GHz F.M. LINK RECEIVER
42
FAST LOG. AMPLIFIER/ DETECTOR
52
I.F. 70MHz
VIDEO
SYNC. SEPARATOR
46
ENVELOPE OF I.F. SIGNAL
40
FILTER AND A.M.DETECTOR
53
SYNC.
VIDEO
MEAN SIGNAL LEVEL
A.M. LEVEL
DECISION CIRCUIT (MICROCOMPUTER)
54
RAMP WAVEFORM REMOVER
48
V.H.F.
30
COMMAND DATA
CAMERA VIDEO OUTPUT
50
V.H.F. DATA-LINK TRANSMITTER
56

FIG. 2

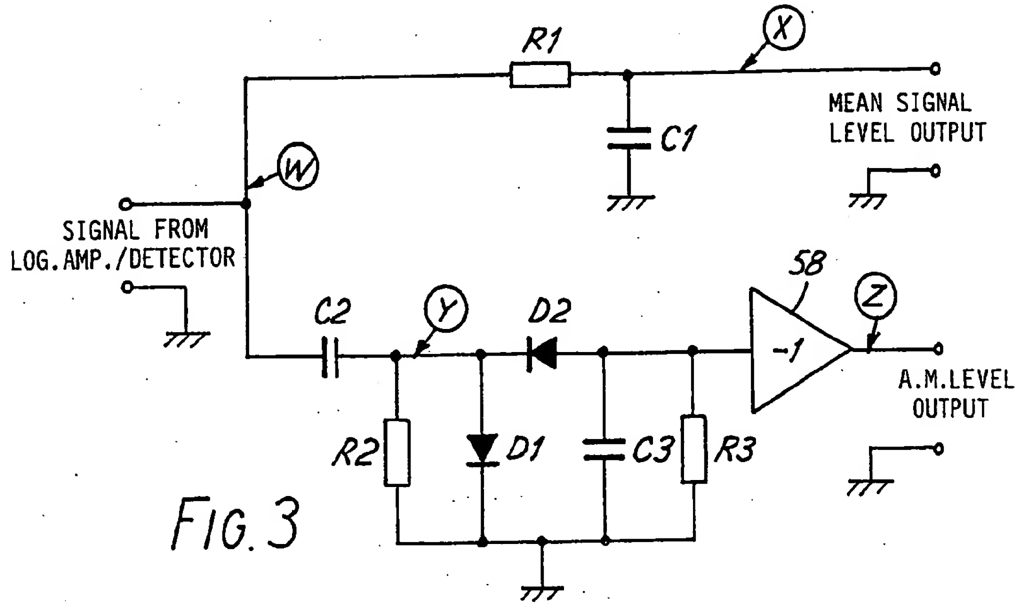
R1
X
C1
MEAN SIGNAL
LEVEL OUTPUT
W
SIGNAL FROM
LOG.AMP./DETECTOR
5B
C2
Y
D2
Z
-1
A.M.LEVEL
OUTPUT
R2
D1
C3
R3

FIG. 3

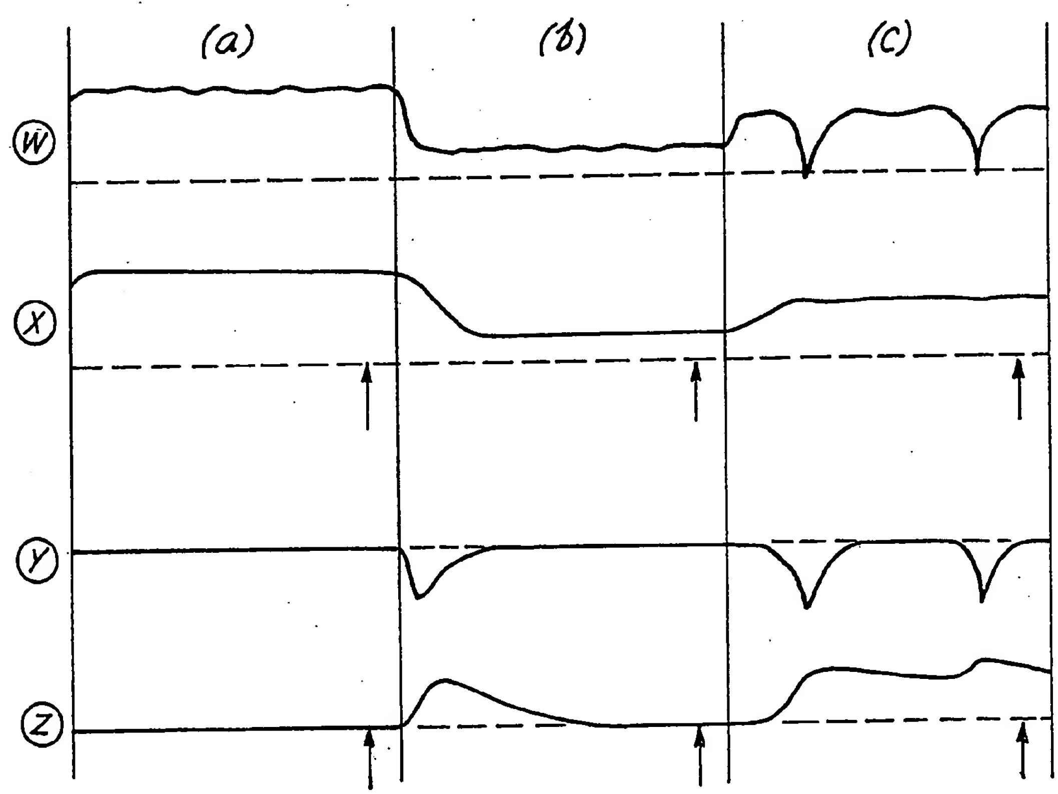
(a)
(b)
(c)
W
X
Y
Z

FIG. 4

SPECIFICATION

Communications system

This invention relates to a radio-frequency comunications system by which signals can be transmitted from a transmitter to a receiver, at least one of which is mobile and thus capable of changing its position and orientation. As a particular example of this the invention will be described in relation to a one-man radio-camera link, namely a link between a hand-held video camera and a fixed receiver, suitable for instance for news-gathering purposes for broadcast television.

We have appreciated that there are several different problems to be overcome by a successful one-man radio-camera system, as follows.

1. Reflection of the radio link signal by the ground and nearby trees and metalwork can give rise to multipath propagation between the transmitter and the receiver. This can cause irrevocable distortion to the video signal (multipath distortion), so directional antennas are necessary to limit the angular ranges over which signals are transmitted and received. Then the physical size of the portable transmitting antenna dictates the use of super-high frequencies.

2. Very fast operation is required at the transmitting end of the link to accommodate all possible movements of the cameraman when he is following very close action.

3. A simple, lightweight tracking system controlling the direction of radio transmission would be able to act in one plane only; the horizontal plane. Since a cameraman can make significant movements about an effective "pitch" axis, the portable antenna must have sufficiently large beamwidth in the vertical plane to accommodate these movements without undue signal loss. Thus, without the weight and complexity of a stabilised platform, the antenna will be unable to combat multipath reflection by objects at ground level, and some degree of multipath distortion will always exist.

4. Whilst in "free-field" conditions (i.e. in the absence of multipath propagation) the r.f. signal strength measured at the receiving end of the link can be used to provide the information necessary to direct the transmitting antenna to track the location of the receiver, when multipath propagation is present this is less reliable. Strong multipath propagation can make the recovered video signal unusable, but cause little change to the r.f. signal strength. This is demonstrated when the added delay of the reflected path (or paths) is similar to the reciprocal of the f.m. bandwidth (1/20MHz = 50ns, corresponding to a path length difference of 15m) and a single steep-sided null appears in the r.f. spectrum of the f.m. channel. This does not abstract a large proportion of the signal power but if, for instance, the null appears at a frequency which normally carries sync. information then, in the demodulated video signal, bursts of noise will appear in the sync. pulses. For all practical purposes the signal will then be unusable. Such reduction in received signal amplitude can be referred to as a "multipath dip".

5. In extreme cases, such as when the direct path from the cameraman to the receiver is obscured by s tree, the only way to preserve the radio link will be to use an alternative path using reflection or diffraction. To switch the tracking system from the direct path instantly to the best of many possible alternative paths, selected for adequately high signal strength and adequately low multipath distortion, will demand speed of operation far beyond the capabilities of rotating machinery.

Thus in mobile operation such as arises with a hand-held video camera when used, typically in physically turbulent surroundings, there are frequent changes in camera orientation and a complex pattern of multipath propagation exists. In many existing systems an extra mobile operator is needed, whose job is to keep the transmitting antenna unobstructed and pointing towards the receiver. This is labour intensive and clumsy because an umbilical cable is required between the cameraman and the extra operator.

Some previous transmission systems have attempted to overcome some of the problems, but none have been completely successful. Reliability problems have been encountered resulting in intermittent operation of the links. For example, GB 2071465 judges the quality of radio signals from several directional antennas by measuring the instantaneous magnitude of a.m. multipath noise on a signal. This is dependent on the instantaneous depth of frequency modulstion. If the system were to be used with a video signal and the measurement occurred during a period of the video signal which contained little picture information a false result would be produced. Also, in US 4101836, a sectional antenna array is used at a radio receiver. The antenna used is determined by the strength of the received signal. However, the system will receive from the same antenna until the received signal strength drops below a predetermined level at which point the antennas are scanned to find which is providing the strongest signal.

The invention in its various aspects is defined in the appended claims to which reference should now be made.

In a preferred embodiment of the invention the transmitter is equipped with a number of antennas, each pointing in a different direction about a vertical axis, and the transmitter is switched selectively to one of the antennas. Switching, such as by means of an array of p.i.n. diodes, can be carried out at very high speed. In the super-high frequency or s.h.f.

band, for example at 12GHz, a cluster of horn antennas need occupy no more physical volume than a single, rotatable horn with a rotary co-axial joint.

If the beamwidths of these antennas are such that their radiation patterns cross at say −3dB, then the only obvious drawback is a loss of up to 3dB in the received signal strength, which, in this case, is of secondary importance. Less obvious problems may lie in the quantisation of the antenna-pointing direction and mutual coupling effects between the apertures of the horns, but both sre functions of the number of horns and the size of the complete antenna, and are therefore open to modification.

In this embodiment the transmitter undertakes a tracking or best-antenna determining operation during each field blanking period. By operating automatically and periodically in this way the signal does not have to fall to a predetermined minimum level before a new determination is made.

The preferred embodiment employs a tracking system which not only uses the received signal strength, but also a simultaneous measurement of the multipath distortion on the link. Both measurements can be accomplished by detecting the envelope of the received r.f. signal when a frequency-swept signal is transmitted, covering the entire bandwidth of the r.f. channel in use. The mean magnitude of the envelope corresponds to the mean signal strength and the magnitude of the ripple component in the envelope corresponds to the degree of multipath propagation. A decision device then applies the dual criteria of sufficiently strong signal and sufficiently low multipath propagation. This may be accomplished by a micro-computer at the fixed receiving end of the link.

Radio links for television outside broadcasts employ frequency modulation almost invariably, and a frequency sweep can then be achieved by feeding to the transmitter a video signal in the form of a "sawtooth" waveform. There are a number of unused lines in the field blanking intervals of the video signal and one or more of these can be used for this purpose. These lines can be blanked out later in the programme chain.

The invention will be described by way of example with reference to the drawings, in which:

Figure 1 is a block circuit diagram of a portable transmitter, showing the multi-horn antenna array;

Figure 2 is a block circuit diagram of an associated fixed receiver;

Figure 3 is a circuit diagram of the filter and a.m. envelope detector; and

Figure 4 shows the waveforms at various points in the filter and a.m. detector circuit.

The preferred system illustrated adapts to using each of the transmitting antennas during each field-blanking interval of the television signal. The link is then established for the duration of the following television field using the transmitting antenna which offered the best quality. In this context 'quality' means the performance of the link with regard to received signal strength and the degree of multipath distortion.

A block diagram of the portable transmitting equipment 10 is illustrated in Figure 1. A conventional s.h.f. link transmitter is used with frequency modulation to carry the video signal. Since the tracking pinciple involves purposeful disruption of the link at each field interval, it is not possible to use an audio-modulated subcarrier on this link. This does not pose a problem because separate radio-microphone systems which can be used for the sound channel are now well established.

The transmitter has an antenna array 12 formed of a cluster of waveguide sectoral horn antennas 1 to 6. A convenient number of horn antennas to mount in a cluster is six, and there are at least six unused lines in each field blanking interval of the television signsl output by an outside broadcast camera. To obtain tracking information at the link receiver, during each field blanking interval the transmitter is switched sequentially to each of the six horns; each for the duration of the active period of one television line (52us).

The camera video signal is applied at a terminal 14 in Figure 1 where it passes to a sync. separator 16. The video signal is then applied to a ramp waveform inserter circuit 18 which adds a sawtooth or ramp waveform to the video signal on each of the six television lines used for tracking purposes. The combined video signal is then applied to a 12GHz f.m. transmitter 20. The r.f. signal is then switched between the six antennas 1 to 6 by a 6-way p.i.n. diode switch 22, in accordance with a switching control signal.

The sync. pulses are used to trigger a ramp waveform generator 24 to generate the ramp waveform for the inserter circuit 18 on each of the six field blanking lines of the video signal which are used for tracking purposes with the six antennas respectively.

The sync. waveform is also applied to a switch controller circuit 26 which applies the switching control signal to the diode switch 22. Additionally a v.h.f. data transmission link 30 from the receiver to the transmitter using a receiver 28 at the transmitter station provides a control signal containing command data to the switch controller 26.

During the active periods of the six field blanking lines used for tracking, the switch controller applies the transmitter signal sequentially to the six horn antennas 1 to 6, while the ramp waveform is included on the video signal. Where the signal is a 625-line

on even fields and lines 318 to 335 on odd fields are unused and may in principle be used for tracking. Thus a cluster of up to 17 horn antennas could be used. However, where there are six horns, as illustrated, lines 6 to 11 and 318 to 323 can conveniently be used. In practice tracking in every field may be unnecessary and thus only lines 6 to 11 on the even fields (for example) can be employed with tracking taking place once per picture.

At all other times when tracking is not taking place the transmitter signal is applied to the horn antenna which the receiver has selected as being the best, in accordance with the signal received over the v.h.f. data link, while the video signal is aplied to the transmitter 20 without modification.

Assuming for the moment that the system is tracking successfully and is receiving the best signal from horn No.3, then the previous television field (lasting 20ms) will have been transmitted by horn No.3. When the field interval occurs, the transmitter will be switched to horn No.1 for the active period of the first line used for tracking, back to No.3 for the next line sync. pulse (because No.3 is known to be giving a usable signal), then to No.2 for the next active line, to No.3 for the next line sync. pulse, and so on.

During these active lines the transmitter will be modulated with the "sawtooth" waveform, with peak excursions corresponding to peak-white and bottom-of-sync. levels.

A block diagram of the fixed receiving equipment 40 is illustrated in Figure 2. A conventional s.h.f. link receiver 44 is used, but it must provide an auxilliary i.f. output, conveniently at 70MHz centre-frequency. This output should be taken from a stage in the receiver before the application of a.g.c.. The receiver is fitted with a horn antenna 42 of moderate beamwidth (e.g. 10°) which, in the simplest form of this system, is directed manually towards the transmitter 10.

The video output of the receiver 44 is applied to a sync. separator 46 and then to a ramp waveform remover 48. This receives sync. pulses separately from the sync. separator 46 and removes the sawtooth waveform which was added to the six lines used for tracking purposes by the inserter circuit 18 at the transmitter. The output of the ramp waveform remover then constitutes the camera video output 50.

The auxilliary i.f. signal is fed to a fast-acting envelope detector 52 (e.g. a logarithmic amplifier/detector). The signal output by the detector then represents the envelope of the received signal. This output then forms the input to a filter and a.m. detector circuit 53. This circuit has two outputs, one is a voltage which represents the mean signal level and is effectively a low-pass filtered version of the log. amp. signal, and the other is a voltage which represents the peak-to-peak magnitude of the a.m. envelope (i.e. the degree of multipath distortion). By relating these outputs to timing derived from television syncs. it is possible to determine which of the transmitting horns gave the strongest signal, and which gave the lowest degree of multipath distortion. This is performed in a decision circuit 54 which has the outputs of the circuit 53 connected to its inputs.

Since the a.m. ripple is measured in the field blanking intervals, when the sawtooth waveform is applied, the transmitted signal is the same from each antenna. Thus, as well as being measured at the same point in each television field, the a.m. measurement is on a known f.m. waveform which can be arranged to explore the full frequency range of the com unication channel. This method provides extremely useful tracking information for the following television field regardless of the picture content of that field. It enables the degree of multi-path distortion for each transmission path to be accurately determined.

If the a.m. ripple detection took place on the camera video signal outside the blanking intervals then, in the tracking periods there would be several lines of noise in each picture. This is because in most circumstances only two or three of the antennas will provide usable signals at the receiver. The use of the field blanking intervals for the transmission of the tracking signal therefore avoids any interference with the received picture.

It is a characteristic of multipath propagation that with for instance two propagation paths, the received signal may rise to twice the voltage for a single path but in the worst case it will fall to zero (− dB) if equal antiphase signals are received over the two paths. This extinction of the f.m. carrier will cause severe disruption of the received TV signal. Transient disruption will lead to bursts of noise at the receiver.

The filter and a.m. detector circuit is shown in Figure 3. A low-pass filter comprising a resistor R1 and a capacitor C1 provides the mean signal level output. The time constant of this filter is less than the line period (64 s for a 625 line signal) but it is sufficiently large to suppress any multipath dips. The a.m. envelope detector is formed by diodes D1 and D2 and various associated components. The input signal is a.c. coupled by a capacitor G2 and a resistor R2 before being applied to the diodes D1 and D2 which are in a conventional voltage doubler arrangement. Capacitor C3 and resistor R3 are connected in parallel from the diode D2 down to earth. An inverting amplifier 58 is also connected to the diode D2. The capacitor C3 is charged negatively by the multipath dips and the resistor R3 provides a decay time constant which is again less the line period. A much longer time constant could however be used here if the capacitor C3 was short-circuited at the end of each television

line by a switch (an FET for instance) to lose any residual charge.

The a.m. detector is followed by the inverting amplifier 58. This amplifier needs to be able to follow line-by-line variations in the signal, but a bandwidth of around 100 KHz rather than the full video bandwidth will suffice. Another bandwidth limitation is imposed by the fact that the rate of attack of the waveform output by the a.m. detector is limited by the output resistance of the log amplifier. However, the number of significant multipath dips which may occur during one line period will be small so this bandwidth limitation will not affect the operation of the circuit.

Figure 4 shows example waveforms at the points W, X, Y and Z in the circuit of Figure 3. The waveforms shown are for three consecutive television lines:

a) is a constant signal level throughout the line with no a.m.;

b) is a different signal level, constant throughout the line with no a.m.; and

c) is a constant mean signal level throughout the line, but with a.m. caused by multipath propogation (multipath dips).

There will be variations in the mean signal level and the degree of a.m. multipath distortion as the transmission changes from one transmitting horn to the next. There will therefore be a transient disturbance at the start of each line and the decision circuit 54 will have to sample the signals at appropriate points in each line. The choice of sampling points will depend on the actual time constants used in the a.m. detector. An example is indicated by the arrows in Figure 4. It is not necessary to sample the a.m. level signal and the mean signal level signal at the same instant.

The decision as to which horn is providing the best signal is made by the decision circuit 54 comprising a microprocessor or microcomputer with the outputs of the filter and a.m. detector circuit as its inputs. These are converted to digital signals by an analogue-to-digital converter at the input. Alternatively, ADCs could be provided at the output of the filter/a.m. detector circuits. The decision is based on a weighted sum of the two contributions; signal strength and freedom from multipath distortion. For example, if horn No.2 is giving less signal strength than No.3 but its signal has less multipath distortion, and its signal strength is sufficient for the receiver to function correctly, then No.2 would be selected rather than No.3. The result of this decision is encoded and applied to a v.h.f. data link transmitter 56 which may typically operate at 68 MHz and which feeds the data transmission link 30. To encode the one-out-of-six information for the selected horn only three data bits are required, plus error protection bits. The signal transmitted over the v.h.f. data link therefore only needs to be a number

The use of a microcomputer to constitute the decision circuit 54 means that the decision process can be made quite complex and variable without altering the hardware. For example the process may be made adaptive to the received signal strength, in particular it can effectively reduce the importance of low multipath distortion when the signal strength is so low as to cause threshold noise in the f.m. link receiver. In these circumstances even a signal with severe multipath distortion would be preferable if it kept the receiver working above threshold. It is possible for the decision circuit 54 to carry out the functions of the filter and a.m. detector circuit 53 by using algorithms within the microprocessor of the decision circuit. However, this would require a much faster analogue-to-digital converter at the input to the decision circuit which would be more expensive.

To achieve the decision and to transmit and receive the data, all before the start of the next television line with picture information on it, demands fast processing, and this offers field= by-field adaptability. With six horns, each having a beamwidth of 60°, the maximum rate of rotation of the camera operator that could be followed would be 60 degrees in 20ms, or 8.32 revolutions per second. This rate of rotation is more rapid than would normally be encountered.

However, if a long delay was put into the system (e.g. by using a very low bandwidth data link) then re-acquisition of tracking after a transient loss of synchronisation could take the duration of several television pictures, and this may be objectionable to the viewer. In practice the loss of more than two fields (one picture) is probsbly the limit of acceptability, so arranging the tracking system for picture-by-picture adaptability should be acceptable and will allow two fields, or 40ms with a 50 Hz field rate, for data processing and communication.

In that case, with six horns, the maximum rate of revolution of the camera operator that could be followed would be about 4 rev./s, which should be adequate for normal operations. The 40ms will allow the use of a low-cost 8-bit microcomputer and a data rate of 300 Baud, or less.

The v.h.f. radio link has been described here for the transmission of the control signal. However, it may be used alternatively to transmit the switching signal, to transmit a signal to generate the control signal at the transmitter. These alternative arrangements would require alternative locations for either the switching signal generating means, or for the control signal generating means respectively.

The action of the system when the equipment is powered initially, or to recover from loss of synchronisation, will be governed by

One possible acquisition strategy would be to transmit consecutive television fields using each of the horns in turn, until television synchronisation is achieved.

It will be seen from the above that, by looking for the best quality of the received signal, not just the highest signal strength but also an adequately low level of multipath distortion, the system directs the transmitted power in the most favourable direction, even if this does not correspond to the direct path between the transmitter and receiver. In some cases it will continue to provide the camera link even when the direct, line-of-sight path is obscured. As long as one of the transmitting horns can irradiate a reflecting object, or the edge of a diffracting object (such as the one which is blocking the direct path), and the received signal strength is sufficient for the receiver to operate correctly, then the link will be preserved, though with perhaps more multipath distortion than would be desired.

The ability to use a special tracking signal, the ramp waveform, and to be able to switch between more than two directional antennas without disrupting the output signal are consequences of the sampled nature of the video signal. Between either each field or each picture a known signal can be transmitted in turn from each antenna and a decision made as to which antenna provides the best received signal in terms of multipath distortion and signal strength.

The consequent effect of switching between propagation paths of different lengths causing advancing and retarding of the timing of the recovered video signal, should be removed completely by the existing synchroniser in the video path from the system output to the television network, providing that consecutive path lengths do not differ by more than about 300m (delay difference =lus).

Evidently a very high-gain directional receiving antenna is not called for in this system because it would preclude the acceptance of alternative paths for the link signal. However, a very low-gain receiving antenna would probably compromise the signal-to-noise ratio of the link and could allow an excessively complex pattern of multipath propagation to exist. Therefore a horn, or small dish antenna, with moderate gain and beamwidth, for instance 10° is to be preferred.

Operation in a restricted area such as a football stadium will not allow the receiver to be located a great distance away from the path of the portable transmitter, and panning of the receiving antenna will be required, though at much lower speed than is required for the transmitting antenna. The system may be enhanced by providing a second, lower-speed tracking system to direct the receiving antenna, and this will further reduce the number of operators required. A conventional Monopulse or Step-Track approach may be applied to this, or it may be possible to duplicate the multi-horn system.

The system is amenable to modifications such as using a fixed transmitter with a plurality of antennas and a mobile receiver and use with signals other than f.m. television. In fact any modulation signal which is discontinuous with time (such as a digital-packet signal) and any constant-envelope modulation scheme (such as MSK) should be applicable. It is also conceivable that such an approach could be adopted for two-way communication.

CLAIMS

1. A radio-frequency com unications system comprising a transmitter station and a receiver station, at least one of which is mobile, in which the transmitter station comprises an array of individually-usable antennas, and means for selecting a desired one of the antennas for use in response to a switching signal, the system including means for generating the switching signal to cause the selecting means automatically and periodically during transmission of a signal to use the antennas sequentially and at other times to use an antenna selected by a control signal, and control signal generating means responsive to the signal received at the receiving station during the periodic sequential selection of antennas to generate the control signal in dependence upon the received signal.

2. A system according to claim 1 in which the switching signal generating means is synchronised to a video signal being transmitted by the transmitter such that the sequential selection of antennas takes place in portions of the video signal which are not normally used to carry picture information.

3. A system according to claim 1 or 2 in which the switching signal generating means controls the sequential selection of antennas to take place during field blanking periods of the video signal.

4. A system according to claim 3 in which the switching signal generating means controls the sequential selection of antennas so that each individual antenna is used during one respective video line of the field blanking period.

5. A system according to any of claims 1 to 4 in which during the periodic sequential selection of antennas a predetermined tracking signal is transmitted and the control signal generating means determines the a.m. ripple on the predetermined tracking signal as each of the antennas is used.

6. A system according to any of claims 1 to 5 which also includes a radio link between the receiver and the transmitter to transmit the control signal or a signal derived therefrom from the receiver to the transmitter.

7. A radio-frequency communications system comprising a transmitter station and a receiver station, at least one of which is mobile, in which the transmitter station comprises an

array of individually-usable antennas, and means for selecting a desired one of the antennas for use in response to a switching signal, the system including means for generating the switching signal to cause the selecting means periodically during transmission of a signal to transmit a predetermined tracking signal using the antennas sequentially and at other times to use an antenna selected by a control signal, and control signal generating means responsive to the signal received at the receiving station during the periodic sequential selection of antennas to determine as each of the antennas are used the a.m. ripple on the predetermined tracking signal.

8. A system according to claim 7 in which the signal received during the sequential selection of antennas is an f.m. signal and is fed to a fast-acting envelope detector.

9. A system according to claim 8 in which the a.m. ripple on the known transmitted signal is detected on the output of the envelope detector by a dedicated electronic circuit producing an output derived from the degree of a.m. ripple.

10. A system according to any of claims 8 or 9 in which the output of the envelope detector is used to determine the signal strength received from each antenna during the sequential selection of antennas.

11. A system according to any of claims 7 to 10 in which the control signal is generated in accordance with a predetermined algorithm in terms of signal strength and signal quality.

12. A system according to any of claims 7 to 11 which also includes a radio link between the receiver and the transmitter to transmit the contral signal or a signal derived therefrom from the receiver to the transmitter.

13. A radio-frequency com unications system comprising a transmitter station and a receiver station, at least one of which is mobile, in which the transmitter station comprises an array of individually-usable antennas, and means for selecting a desired one of the antennas for use in response to a switching signal, the system including means for generating the switching signal to cause the selecting means periodically during transmission of a signal to use the antennas sequentially and at other times to use an antenna selected by a control signal, control signal generating means responsive to the signal received at the receiving station during the periodic sequential selection of antennas, and a radio link between the receiver and the transmitter to transmit the control signal or a signal derived therefrom from the receiver to the transmitter.

14. A system according to claim 13 in which the switching signal generating means and the control signal generating means are at the receiver, and the signal transmitted by the radio link is the switching signal.

15. A radio frequency communications sys-

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